学位論文内容の要旨

博士の専攻分野名称：博士（農学）　　氏　名：Mengjie Li

学位論文題名

Factors controlling episodic soil CO_2 and N_2O emissions from managed grassland and corn field in southern Hokkaido, Japan

(北海道南部の草地、飼料畑土壌からの突発的CO_2およびN_2O排出の制御因子)

Nitrous oxide (N_2O) and carbon dioxide (CO_2) emissions from soil were highly variable in time caused by the complex set of environmental variables such as soil temperature and moisture, soil organic matter (SOM) content, O_2 status as well as nutrient availability. Gas fluxes at hot moment frequently accounts for larger proportion of greenhouse gas (GHG) budgets. Temporal heterogeneity is accentuated in agricultural relative to non-managed landscapes. Land management causes physical and biogeochemical disturbance of extreme magnitude and in pulsed events. Episodic high CO_2 and N_2O fluxes have been reported after events including drying-rewetting, rainfall, freezing-thawing, fertilizer and manure additions, harvest and tillage. Therefore understanding the temporal variability of CO_2 and N_2O fluxes is key importance to reliably estimate these gases fluxes and to develop mitigation strategies. In this study, episodic N_2O and CO_2 fluxes at hot moments in managed grassland and cornfield was evaluated by box plot method, and the effects of nutrient management and soil properties associated with tillage including bulk density, soil moisture content, aggregate size on CO_2, N_2O and NO emissions were studied by laboratory incubation, and then to identify key factors affecting the episodic CO_2 and N_2O emission.

1. Evaluation of N_2O and CO_2 hot moments in managed grassland and cornfield

Soil N_2O and CO_2 fluxes from managed grassland and cornfield in Shizunai and Shin-Hidaka, Hokkaido, Japan were monitored by closed chamber at plots applied with fertilizer (F), manure plus fertilizer (MF), and no-fertilizer (CT). The N_2O and CO_2 fluxes at hot moments were analyzed by box plot method. The characteristics of N_2O and CO_2 hot moments were generally similar in two sites but varied between grassland

and cornfield. Threshold of N_2O peak event was higher in cornfield than in grassland due to higher rates of fertilization and mineralization. Events of temperature > 20 °C, rainfall, harvest, fertilizer and manure applications significantly promoting N_2O hot moment in grassland, while only rainfall event significantly induced N_2O hot moment in cornfield. More sensitive response of N_2O hot moment to fertilizers addition event in grassland can be attributed to the much lower NO_3^- contents. Greater magnitude of N_2O hot moment in cornfield after rainfall event was caused by more sufficient N supply for denitrification. Except the contribution of N_2O hot moment in cornfield of Shin-Hidaka ranged from 5.9%~19.4%, N_2O hot moment accounted for more than one-third of the annual total emissions in F and MF plots. The CO_2 flux was strongly controlled by soil temperatures, and much less episodic than N_2O flux. Therefore mitigating episodic N_2O flux would greatly reduce annual N_2O production, and fertilization avoiding rainfall in grassland could be one option.

2. The mechanism of key factors inducing episodic CO_2 and N_2O fluxes

The CO_2 and N_2O productions of repacked soil cores with different aggregate sizes (0~2, 2~4.5mm), gravimetric water contents (GWC 0.35, 0.45 g g^{-1}) and bulk densities (BD 0.45, 0.66 g cm^{-3}) were studied by incubation. The insignificant effects of BD, GWC or nutrient management on CO_2 flux contributed to the less episodic nature of CO_2 fluxes in field. Higher microbial biomass carbon (MBC) and water extractable organic carbon (WEOC) contents lead to greater CO_2 production in larger aggregate. The enhanced aeration by tillage was not likely to induce CO_2 hot moment due to the poor relationship between air-ratio with CO_2 emission. Optimal soil moisture for CO_2 emission was wildly provided from 29~83% water filled pore space (WFPS), partly explaining the weak effect of rainfall on CO_2 hot moment. Manure addition enhanced N_2O emission by providing higher NO_3^-. The extremely high N_2O production of high GWC and high BD treatments with 80% WFPS was owed to higher denitrification rate, and N_2O emission at low WFPS was generally small. This implied that the prompt increase in N_2O emission by rainfall was more typical for denitrification. Larger aggregate emitted more N_2O at low WFPS due to more anaerobic volume created by quicker soil respiration rate. N_2O production was much higher in small aggregate at 80% WFPS caused by greater NO_3^- supply by nitrification. Besides high WFPS, soil mineral N was required for high episodic N_2O emissions. Low NO_3^- level and high WFPS led to high potential of N_2O peak induced by fertilizer addition in grassland.